Ultrasonography of the abomasum in 30 Saanen goats

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Abstract: This report describes the findings of ultrasonographic examination of the abomasum in 30 goats. A 5.0 MHz linear transducer was used to scan the left and right paramedian regions, the linea alba and the right abdominal wall of standing goats. The abomasum appeared as a heterogeneous, moderately echogenic structure with echogenic stippling. The abomasum could be seen from the linea alba in all the goats. The abomasal folds were easily identified in 19 goats and appeared as prominent echogenic bands. The cranial visible limit of the abomasum was −0.3 [2.34] cm from the xyphoid, and the caudal limit was 10.3 [3.08] cm caudal to the xyphoid. The visible length of the abomasum was 10.7 [1.96] cm and the maximum width 30.2 [7.43] cm. The height of the abomasum was 6.7 [1.79] cm.

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Short Communication: Ultrasonography of the abomasum in 30 Saanen goats

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ABSTRACT

This report describes the findings of ultrasonographic examination of the abomasum in 30 goats. A 5.0 MHz linear transducer was used to scan the left and right paramedian regions, the linea alba and the right abdominal wall of standing goats. The abomasum appeared as a heterogeneous, moderately echogenic structure with echogenic stippling. The abomasum could be seen from the linea alba in all the goats. The abomasal folds were easily identified in 19 goats and appeared as prominent echogenic bands. The cranial visible limit of the abomasum was -0.3 [2.34] cm from the xyphoid, and the caudal limit was 10.3 [3.08] cm caudal to the xyphoid. The visible length of the abomasum was 10.7 [1.96] cm and the maximum width 30.2 [7.43] cm. The height of the abomasum was 6.7 [1.79] cm.

Keywords: Goat; Abomasum; Ultrasonography

The abomasum in goats is situated mainly in the cranioventral region of the abdomen (Cegarra and Lewis, 1977). Compared with cattle, the caprine abomasum is proportionally larger and has a capacity of 2.1 to 4.0 litres in adults (Smith and Sherman, 2009). Abomasal diseases may affect young as well as older goats. Pyloric obstruction by phytobezoars has been described in adult goats (Bath, 1978; Bath and Berg, 1979). Abomasal emptying defects, which are part of functional pyloric stenosis in cattle, have also been reported in goats (Edwards and Nevel, 2008). Abomasal impaction is seen mainly in goats ingesting feeds high in indigestible fibre and not drinking adequate amounts of water (Linklater and Smith, 1993; Matthews, 2009b). Abomasal impaction attributable to metal particles has also been described (Purohit et al., 1986). *Haemonchus contortus* and *Teladorsagia circumcincta* are two important endoparasites that affect the abomasum (Matthews, 2009a). Severe haemonchosis results in oedema and congestion of the abomasal mucosa and marked enlargement of the abomasal lymph nodes (Pérez et al., 2001). Retrograde congestion of the abomasum attributable to

53 ileus of the small intestine has been described in cattle (Braun, 2003) and has been reported in a goat
54 with duodenal obstruction caused by a phytobezoar (Sherman, 1981). In contrast to cattle, left and
55 right displacement of the abomasum is extremely rare in goats (Smith and Sherman, 2009). There is
56 only one case report in the literature (West et al., 1983). Thorough evaluation of the normal
57 abomasum cannot be achieved by physical examination alone. Since ultrasonography has been used to
58 evaluate the abomasum in healthy cows (Braun et al., 1997a) and in cows with left (Braun et al.,
59 1997b) and right abomasal displacement (Braun and Feller, 2008) as well in calves to study the
60 position, capacity and rate of emptying of the abomasum (Wittek et al., 2005), it was the goal of the
61 present study was to describe the position, size and appearance of the abomasum in 30 healthy Saanen
62 goats. The information would provide reference values when evaluating goats with abomasal disease.
63
64 Thirty clinically healthy, non-lactating female Saanen goats, which were 2.5 to 6.5 years old,
65 were used. They were fed hay ad libitum and not fasted before the ultrasonographic examination. The
66 study protocol was approved by the Animal Care Committee of the Canton of Zurich, Switzerland.
67 Ultrasonographic examinations were carried out in standing, non-sedated animals using a 5.0
68 MHz linear or convex transducer with a penetration depth of 10 cm, as described recently (Jacquat,
69 2010). The abomasum was examined from the right and left paramedian regions, the linea alba and the
70 right abdominal wall. The location of the abomasum and appearance of its wall, folds and contents
71 were assessed. Neighbouring organs were identified. The visible size of the abomasum was determined
72 using the method described for cattle (Braun et al., 1997a). Identification of the cranial and caudal
73 limits of the abomasum were evaluated from the linea alba. The distance between the cranial and
74 caudal abomasal limits and the caudal end of the xyphoid was measured with a measuring tape (Fig. 1).
75 The distance between the two limits was considered the visible length of the abomasum in the region
76 of the linea alba (Fig. 2). The width of the abomasum was determined at the point where the maximum

77 transverse dimension of the abomasum was seen. A measuring tape was used to measure the distance
78 from the linea alba to the maximum right and left abomasal limits. The vertical dimension of the
79 abomasum (abomasal height) was determined electronically from the linea alba at the point where the
80 maximum vertical dimension of the abomasum was seen (Fig. 2).
81 After examination, the goats were slaughtered (n = 14) or euthanized (n = 16). A
82 macroscopic postmortem examination of the abomasum was carried out in the slaughtered goats. The
83 euthanased goats, which were also used in other studies (Becker-Birck, 2009; Steininger, 2009; Irmer,
84 2010), were frozen and cut into 1.0 to 1.5 cm-thick transverse sections. On each transverse section the
85 abomasum was examined.
86
87 The abomasum appeared as a heterogeneous, moderately echogenic structure with echogenic
88 stippling, similar to the description reported in cattle (Braun et al., 1997a; Braun, 2003) (Fig. 3). The
89 abomasum could always be differentiated from the neighbouring organs. It could be seen from the
90 linea alba in all the goats and was directly adjacent to the abdominal wall in this region. The abomasum
91 was visible from the right or left paramedian region in all the goats but it was seen from both sides in
92 only 29. The abomasal wall could not be seen in any of the goats. The abomasal folds were easily
93 recognised in 19 goats and appeared as prominent echogenic bands (Fig. 4). However, in eight goats
94 they were difficult to identify and in two, they could not be seen at all. The abomasal folds were seen
95 particularly well during reticular contractions. The pylorus could be clearly identified in only one goat
96 (Fig. 5). It was round with a hypoechogenic lumen and an echogenic torus pyloricus and pyloric folds.
97 The torus pyloricus was seen vaguely in five other goats.
98 The abomasum could be visualised equally well from either side and was approximately the
99 same size on the left and right. It occupied more space cranially on the left but more space caudally on
100 the right where it extended over a larger distance than on the left. From the linea alba, the visible

101 cranial limit of the abomasum was -0.3 [2.34] cm from the xyphoid and the caudal limit was 10.3
102 [3.08] cm caudal to the xyphoid. The visible length of the abomasum ranged from 7.0 cm to 15.0 cm
103 (10.7 [1.96] cm). The maximum width of the abomasum was 30.2 [7.43] cm and it occupied equal
104 space on the left (15.1 [3.72] cm) and right (15.2 [3.71] cm) sides of the linea alba. The height of the
105 abomasum was 6.7 [1.79] cm (3.3 – 10.6 cm).

106 The reticulum was seen cranial to the abomasum when viewed from the linea alba in all the
107 goats, and the ventral sac of the rumen was observed caudal to the abomasum in all the goats. From
108 the right side, loops of small intestine were seen caudal to the abomasum in all but one goat. In 25
109 goats, the liver was seen on the right side and was lateral or dorsal to the abomasum. The gallbladder
110 was situated immediately dorsal to the abomasum in six goats, and the omasum was observed dorsal to
111 the abomasum in 21 goats.

112 *Haemonchus contortus* was found in the abomasum of nine goats. The abomasal mucosa
113 appeared macroscopically normal. There were no other abnormal findings.

114

115 The ultrasonographic appearance of the abomasum allowed it to be easily differentiated from
116 adjacent organs. Its contents were hypoechogenic with hyperechogenic stippling, similar to that seen in
117 cattle (Braun et al., 1997a). However, there were distinct differences in the degree of homogeneity or
118 echogenicity of the abomasal contents among the goats. The abomasal folds were best seen with
119 homogeneous anechogenic or hypoechogenic abomasal contents and when the abomasum moved
120 cranially during a reticular contraction. It was very difficult to observe the pylorus because of the small
121 intestines, which were normally located in the caudal abomasal region. The pylorus was seen clearly in
122 only one goat. Similar findings were reported in cattle, in which the pylorus could be seen in only one
123 of 50 cows (Wild, 1995; Braun et al., 1997). The abomasal wall could not be easily differentiated from
124 the contents and abdominal wall and thus its thickness was not measured in any of the goats. The

abomasal wall in cows was described as a thin echogenic line (Wild, 1995; Braun et al., 1997a). In contrast to cattle, the caprine abomasum could be seen equally well and yielded similar measurements on both sides. The visible length of the abomasum in the region of the linea alba was 7.0 to 15.0 cm. The visible length in cattle ranged from 7.4 to 42.9 cm (Braun et al., 1997a). When determining the size of the abomasum in the region of the linea alba, one must remember that the abomasum is located between the reticulum and rumen and therefore, the measured length does not reflect the actual length. This also applies for the height of the abomasum. It is often difficult to measure the height of the abomasum in the region of the linea alba because the depth of the organ is beyond the capacity of the transducer, or gas within the organ prevents adequate visualisation of the organ. Therefore, the measurements are highly dependent on the visibility of the abomasum and the nature of its contents. The findings of this study show that ultrasonography is very useful for the diagnosis of abomasal disorders in goats such as left displacement, enlargement caused by pyloric stenosis or retrograde dilation in animals with ileus. It is plausible that thickening of the abomasal wall caused by lymphosarcoma can also be diagnosed via ultrasonography. However, based on findings in cattle, it is unlikely that abomasal ulcers can be detected on ultrasonograms.

Conclusions

The results serve as reference values for ultrasonographic evaluation of the abomasum in goats. Ultrasonography is an important tool for non-invasive diagnosis of abomasal disorders in goats because conventional methods for examining this organ are limited. Ultrasonography provides information about the location, size and contents of the caprine abomasum. Knowledge of the normal ultrasonographic features of the abomasum is required for interpretation of lesions.

Conflict of interest statement

149 The authors of this paper have no financial or personal relationship with other people or
150 organisations that could inappropriately influence or bias the content of the paper.
151
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202

203 **Legends to figures**

204 Figure 1: Schematic representation of the location, length and width of the abomasum in Saanen goats.
205 A Xyphoid, B Abomasum, 1 Distance between the cranial abomasal limit and the end of the
206 xyphoid, 2 Distance between the caudal abomasal limit and the end of the xyphoid, 3 Visible length
207 of the abomasum, 4 Visible width of the abomasum.

208 Figure 2: Schematic representation of determination of the height and length of the abomasum in
209 Saanen goats. A Reticulum, B Anterior dorsal blind sac of the rumen, C Dorsal sac of the rumen, D
210 Ventral sac of the rumen, E Abomasum, 1 Visible height of the abomasum, 2 Visible length of the
211 abomasum.

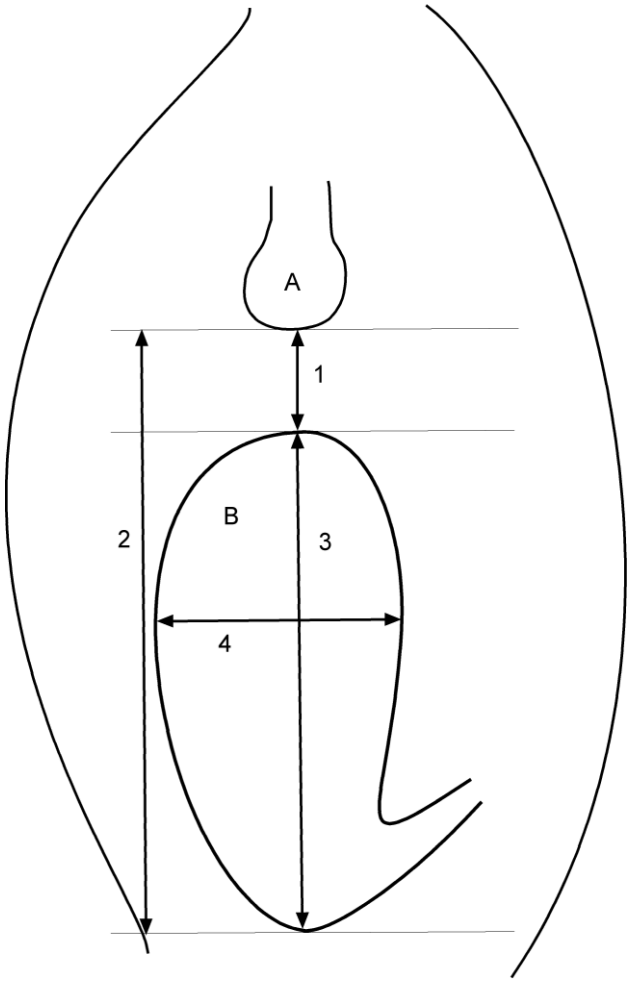
212 Figure 3: Ultrasonogram of the abomasum of a five-year-old Saanen goat, viewed from the left ventral
213 paramedian region using a 5.0 MHz convex transducer. The abomasum is seen caudal to the
214 reticulum and appears as a heterogeneous, moderately echogenic structure with multifocal
215 echogenic foci. 1 Abdominal wall, 2 Abomasum, 3 Reticulum, Cr Cranial, Cd Caudal.

216 Figure 4 : Ultrasonogram showing an abomasal fold in a 3.5-year-old Saanen goat, viewed from the
217 left ventral paramedian region using a 5.0 MHz convex transducer. The abomasal fold is seen as
218 echogenic, undulating structure within the abomasal contents. 1 Abdominal wall, 2 Reticulum, 3
219 Abomasum, 4 Abomasal fold, Cr Cranial, Cd Caudal.

220 Figure 5 : Ultrasonogram showing the pylorus in a four-year-old Saanen goat, viewed from the 10th
221 intercostal space on the right using a 5.0 MHz linear transducer. The pylorus has a heterogenous
222 echogenic appearance and is round to oval in cross section. 1 Lateral abdominal wall, 2 Pylorus, 3
223 Small intestines, Ds Dorsal, Vt Ventral.

224

225 Figure 1



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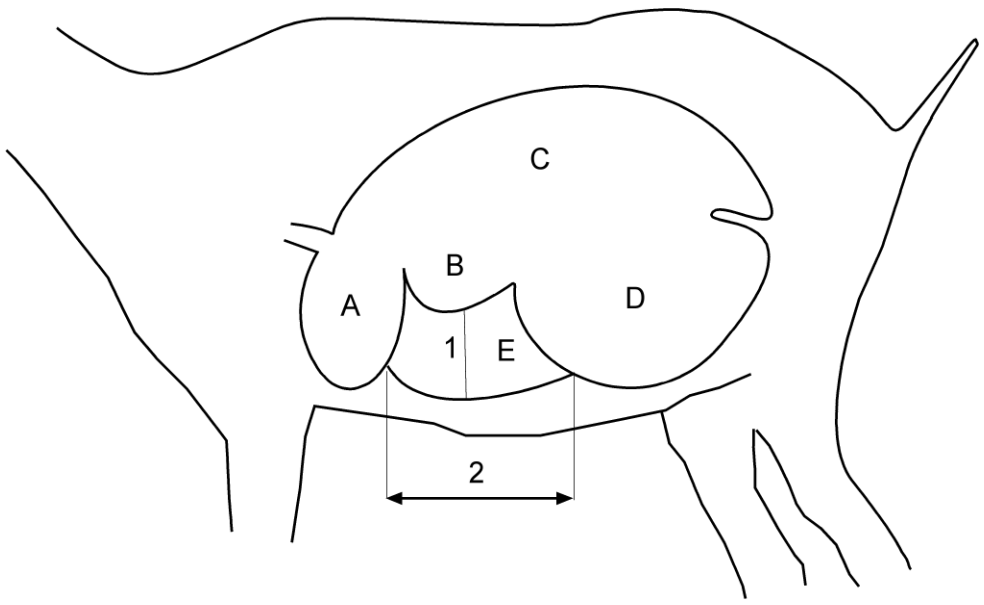
228 Figure 2



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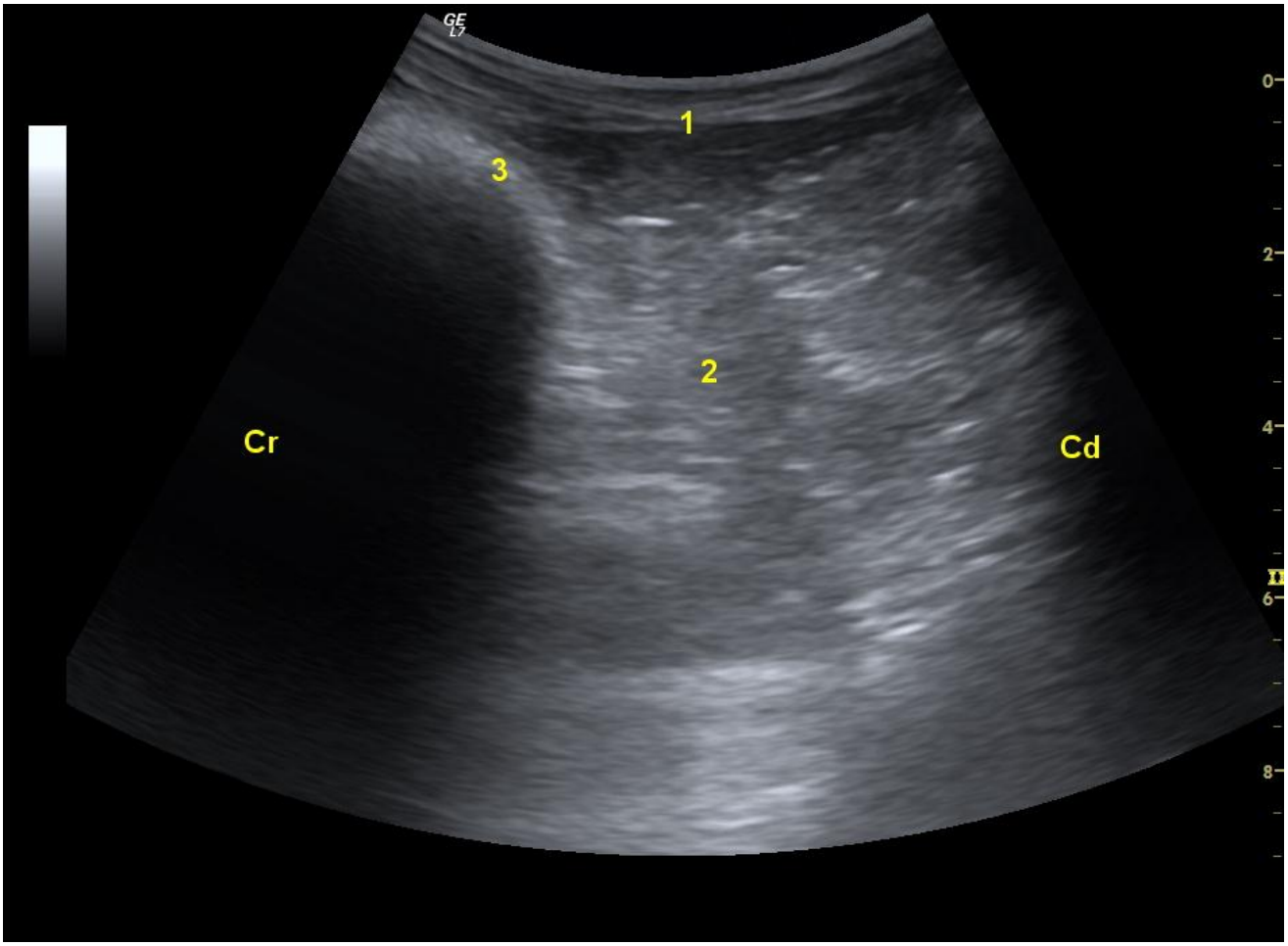
230 Figure 3



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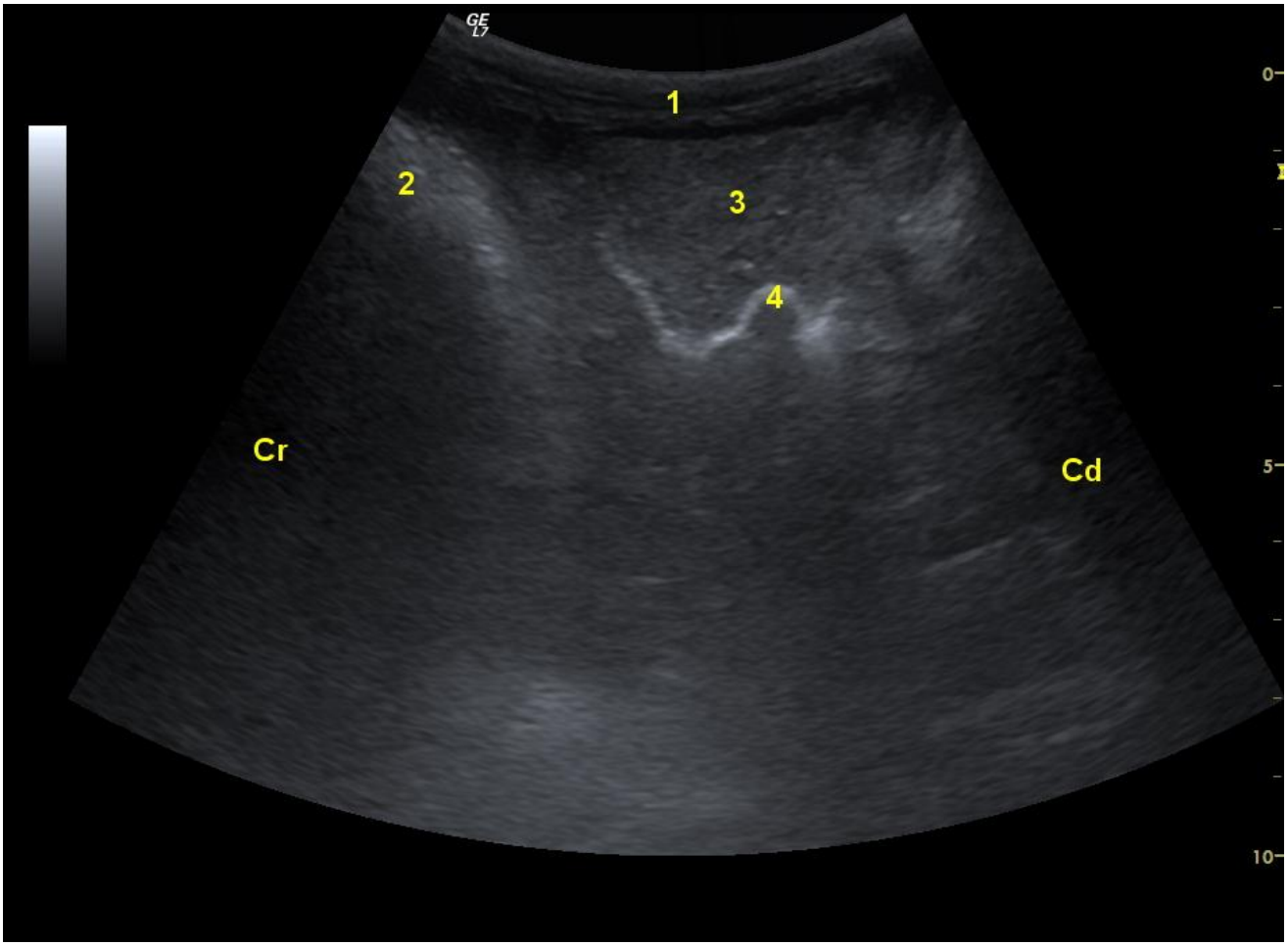
234 Figure 4



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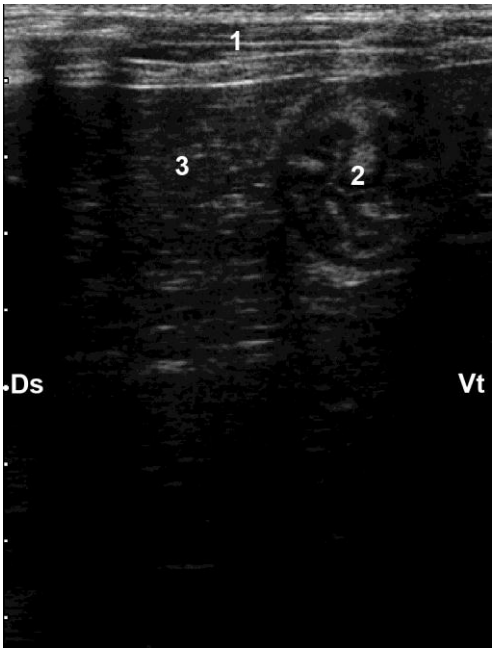
238 Figure 5



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